Selection of Rail Routes. Rail transportation routing of spent nuclear fuel and high-level radioactive waste shipments is not regulated by the U.S. Department of Transportation. As a consequence, the routing rules used by the INTERLINE computer program (DIRS 104781-Johnson et al. 1993, all) assumed that railroads would select routes using historic practices. DOE has determined that the INTERLINE program is appropriate for calculating routes and related information for use in transportation analyses (DIRS 101845-Maheras and Pippen 1995, pp. 2 to 5). Because the routing of rail shipments would be subject to future, possibly different practices of the involved railroads, DOE could use other rail routes. Section J.4 contains maps of the rail routes used in the analysis along with estimated impacts of rail shipments for each state.

For the 24 commercial sites that have the capability to handle and load rail casks but do not have direct rail service, DOE used the HIGHWAY computer program to identify routes for heavy-haul transportation to nearby railheads. For such routes, routing agencies in affected states would need to approve the transport and routing of overweight and overdimensional shipments.

J.1.2.2.2 *Routes for Shipping Rail Casks from Sites Not Served by a Railroad*

In addition to routes for legal-weight trucks and rail shipments, 24 commercial sites that are not served by a railroad, but that have the capability to load rail casks, could ship spent nuclear fuel to nearby railheads using heavy-haul trucks (see Table J-11). In addition, six of the sites that initially are legal-weight truck sites would be indirect rail sites after plant shutdown.

J.1.2.2.3 *Sensitivity of Analysis Results to Routing Assumptions*

Routing for shipments of spent nuclear fuel and high-level radioactive waste to the proposed repository would comply with regulations of the U.S. Department of Transportation and the Nuclear Regulatory Commission in effect at the time shipments would occur. Unless the State of Nevada designates alternative or additional preferred routes, to comply with U.S. Department of Transportation regulations all preferred routes would ultimately enter Nevada on Interstate 15 and travel to the repository on U.S. Highway 95. States can designate alternative or additional preferred routes for highway shipments. At this time the State of Nevada has not identified any alternative or additional preferred routes DOE could use for shipments to the repository. Section J.3.1.3 examines the sensitivity of transportation impacts both nationally and regionally (within Nevada) to changes in routing assumptions within Nevada.

J.1.3 ANALYSIS OF IMPACTS FROM INCIDENT-FREE TRANSPORTATION

DOE analyzed the impacts of incident-free transportation for shipments of commercial and DOE spent nuclear fuel and DOE high-level radioactive waste that would be shipped under the Proposed Action and Inventory Modules 1 and 2 from 77 sites to the repository. The analysis estimated impacts to the public and workers and included impacts of loading shipping casks at commercial and DOE sites and other preparations for shipment as well as intermodal transfers of casks from heavy-haul trucks or barges to rail cars.

J.1.3.1 Methods and Approach for Analysis of Impacts for Loading Operations

The analysis used methods and assessments developed for spent nuclear fuel loading operations at commercial sites to estimate radiological impacts to involved workers at commercial and DOE sites. Previously developed conceptual radiation shield designs for shipping casks (DIRS 101747-Schneider et al. 1987, Sections 4 and 5), rail and truck shipping cask dimensions, and estimated radiation dose rates at locations where workers would load and prepare casks (DIRS 104791-DOE 1992, p. 4.2) for shipment were the analysis bases for loading operations. In addition, tasks and time-motion evaluations from these studies were used to describe spent nuclear fuel handling and loading. These earlier evaluations were based on normal, incident-free operations that would be conducted according to Nuclear Regulatory Commission regulations that establish radiation protection criteria for workers.

The analysis assumed that noninvolved workers would not have tasks that would result in radiation exposure. In a similar manner, the analysis projected that the dose to the public from loading operations would be extremely small, resulting in no or small impacts. A separate evaluation of the potential radiation dose to members of the public from loading operations at commercial nuclear reactor facilities showed that the dose would be very low, less than 0.001 person-rem per metric ton uranium of spent nuclear fuel loaded (DIRS 104731-DOE 1986, p. 2.42, Figure 2.9). Public doses from activities at commercial and DOE sites generally come from exposure to airborne emissions and, in some cases, waterborne effluents containing low levels of radionuclides. However, direct radiation at publicly accessible locations near these sites typically is not measurable and contributes negligibly to public dose and radiological impacts. Though DOE expects no releases from loading operations, this analysis estimated that the dose to the public would be 0.001 person-rem per metric ton uranium, and metric ton equivalents, for DOE spent nuclear fuel and high-level radioactive waste. Noninvolved workers could also be exposed to low levels of radioactive materials and radioactivity from loadout operations. However, because these workers would not work in radiation areas they would receive a very small fraction of the dose received by involved workers. DOE anticipates that noninvolved workers would receive individual doses similar to those received by members of the public. Because the population of noninvolved workers would be small compared to the population of the general public near the 77 sites, the dose to these workers would be a small fraction of the public dose.

The analysis used several basic assumptions to evaluate impacts from loading operations at DOE sites:

- Operations to load spent nuclear fuel and high-level radioactive waste at DOE facilities would be similar to loading operations at commercial facilities.

- Commercial spent nuclear fuel would be in storage pools or in dry storage at the reactors and DOE spent nuclear fuel would be in dry storage, ready to be loaded directly in Nuclear Regulatory Commission-certified shipping casks and then on transportation vehicles. In addition, DOE high-level radioactive waste could be loaded directly in casks. All preparatory activities, including packaging, repackaging, and validating the acceptability of spent nuclear fuel for acceptance at the repository would be complete prior to loading operations.

- Commercial spent nuclear fuel to be placed in the shipping casks would be uncanistered or canistered fuel assemblies, with at least one assembly in a canister. DOE spent nuclear fuel and high-level radioactive waste would be in disposable canisters. Typically, uncanistered assemblies would be loaded into shipping casks under water in storage pools (wet storage). Canistered spent nuclear fuel could be loaded in casks directly from dry storage facilities or storage pools.

In addition, because handling and loading operations for DOE spent nuclear fuel and high-level radioactive waste and commercial spent nuclear fuel would be similar, the analysis assumed that impacts to workers during the loading of commercial spent nuclear fuel could represent those for the DOE materials, even though the radionuclide inventory of commercial fuel and the resultant external dose rate would be higher than those of the DOE materials. This conservative assumption of selecting impacts from commercial handling and loading operations overestimated the impacts of DOE loading operations, but it enabled the use of detailed real information developed for commercial loading operations to assess impacts for DOE operations. Equivalent information was not available for operations at DOE facilities. To gauge the conservatism of the assumption DOE compared the radioactivity of contents of shipments of commercial and DOE spent nuclear fuel and high-level radioactive waste. Table J-12 compares typical inventories of important contributors to the assessment of worker and public health impacts. These are cesium-137 and actinide isotopes (including plutonium) for rail shipments of commercial spent nuclear

Table J-12. Average cesium-137, actinide isotope, and total radioactive material content (curies) in a rail shipping cask.[a]

Material	Cesium-137	Actinides	Total (all isotopes)
Commercial spent nuclear fuel (PWR)[b]	816,000	694,000	2,130,000
High-level radioactive waste	27,000	53,000[c]	180,000
DOE spent nuclear fuel (except naval spent nuclear fuel)	119,000	40,000	265,000
Naval spent nuclear fuel	450,000	28,000	1,100,000

a. Source: Appendix A. Source estimated based on 24 typical pressurized-water reactor fuel assemblies for commercial spent nuclear fuel; one dual-purpose shipping canister for naval spent fuel; nine canisters of DOE spent nuclear fuel; and five canisters of high-level radioactive waste.
b. PWR = pressurized-water reactor.
c. Includes immobilized plutonium with high-level radioactive waste.

fuel, DOE spent nuclear fuel, and DOE high-level radioactive waste. Although other factors are also important (for example, material form and composition), these indicators provide an index of the relative hazard potential of the materials. Appendix A contains additional information on the radionuclide inventory and characteristics of spent nuclear fuel and high-level radioactive waste.

J.1.3.1.1 *Radiological Impacts of Loading Operations at Commercial Sites*

In 1987, DOE published a study of the estimated radiation doses to the public and workers resulting from the transport of spent nuclear fuel from commercial nuclear power reactors to a hypothetical deep geologic repository (DIRS 101747-Schneider et al. 1987, all). This study was based on a single set of spent nuclear fuel characteristics and a single split [30 percent/70 percent by weight; 900 metric tons uranium/2,100 metric tons uranium per year] between truck and rail conveyances. DOE published its findings on additional radiological impacts on monitored retrievable storage workers in an addendum to the 1987 report (DIRS 104791-DOE 1992, all). The technical approaches and impacts summarized in these DOE reports were used to project involved worker impacts that would result from commercial at-reactor spent nuclear fuel loading operations. DOE did not provide a separate analysis of noninvolved worker impacts in these reports. For the analysis in this EIS, DOE assumed that noninvolved workers would not receive radiation exposures from loading operations. This assumption is appropriate because noninvolved workers would be personnel with managerial or administrative support functions directly related to the loading tasks but at locations, typically in offices, away from areas where loading activities took place.

In the DOE study, worker impacts from loading operations were estimated for a light-water reactor with pool storage of spent nuclear fuel. The radiological characteristics of the spent nuclear fuel in the analysis was 10-year-old, pressurized-water reactor fuel with an exposure history (burnup) of 35,000 megawatt-days per metric ton. In addition, the reference pressurized-water reactor and boiling-water reactor fuel assemblies were assumed to contain 0.46 and 0.19 MTU, respectively, prior to reactor irradiation. The term MTU (metric ton of uranium) is from the DOE study. An MTU is approximately the same quantity of spent nuclear fuel as a metric ton of heavy metal, or MTHM, as described in this EIS. In this section, the terms are used interchangeably to allow the information reported in prior DOE studies to be used without modification. These parameters for spent nuclear fuel are similar to those presented in Appendix A of this EIS. The use of the parameters for spent nuclear fuel presented in Appendix A would be likely to lead to similar results.

In the 1987 study, radiation shielding analyses were done to provide information on (1) the conceptual configuration of postulated reference rail and truck transportation casks, and (2) the direct radiation levels at accessible locations near loaded transportation casks. The study also presented the results of a detailed time-motion analysis of work tasks that used a loading concept of operations. This task analysis was coupled with cask and at-reactor direct radiation exposure rates to estimate radiation doses to involved workers (that is, those who would participate directly in the handling and loading of the transportation casks and conveyances). Impacts to members of the public from loading operations had been shown to be small [fraction of a person-millirem population dose; (DIRS 101747-Schneider et al. 1987, p. 2.9)] and were eliminated from further analysis in the 1987 report. The at-reactor-loading concept of operations included the following activities:

1. Receiving the empty transportation cask at the site fence
2. Preparing and moving the cask into the facility loading area
3. Removing the cask from the site prime mover trailer
4. Preparing the cask for loading and placing it in the water-filled loading pit
5. Transferring spent nuclear fuel from its pool storage location to the cask
6. Removing the cask from the pool and preparing it for shipment
7. Placing the cask on the site prime mover trailer
8. Moving the loaded cask to the site fence where the trailer is connected to the transportation carrier's prime mover for offsite shipment

The results for loading operations are listed in Table J-13.

Table J-13. Principal logistics bases and results for the reference at-reactor loading operations.[a]

Parameter	Conveyance		
	Rail[b]	Truck[c]	Total
Annual loading rate (MTU/year)[d]	2,100	900	3,000
Transportation cask capacity, PWR - BWR (MTU/cask)	6.5 - 6.7	0.92 - 0.93	NA[e]
Annual shipment rate (shipments/year)	320	970	1,290
Average loading duration,[f] PWR - BWR (days)	2.3 - 2.5	1.3 - 1.4	NA
Involved worker specific CD,[g] PWR - BWR (person-rem/MTU)	0.06 - 0.077	0.29 - 0.31	NA

a. Source: DIRS 101747-Schneider et al. (1987, pp. 2.5 and 2.7).
b. 14 pressurized-water reactor and boiling-water reactor spent nuclear fuel assemblies per rail transportation cask.
c. 2 pressurized-water reactor and boiling-water reactor spent nuclear fuel assemblies per truck transportation cask.
d. MTU = metric tons of uranium. One MTU is approximately equal to 1 MTHM.
e. NA = not applicable.
f. Based on single shift operations; carrier drop-off and pick-up delays were not included.
g. Collective dose expressed as the sum of the doses accumulated by all loading (involved) workers, regardless of the total number of workers assigned to loading tasks.

The loading activities that the study determined would produce the highest collective unit impacts are listed in Table J-14. As listed in this table, the involved worker collective radiation doses would be dominated by tasks in which the workers would be near the transportation cask when it contained spent nuclear fuel, particularly when they were working around the cask lid area. These activities would deliver at least 40 percent of the total collective worker doses. Worker impacts from the next largest dose-producing tasks (working to secure the transportation cask on the trailer) would account for 12 to 19 percent of the total impact. The impacts are based on using crews of 13 workers [the number of workers

Table J-14. At-reactor reference loading operations—collective impacts to involved workers.[a]

Task description	Rail		Truck	
	CD per MTU[b,c] (PWR - BWR)[d]	Percent of total impact	CD per MTU (PWR - BWR)	Percent of total impact
Install cask lids; flush cask interior; drain, dry and seal cask	0.025 - 0.024	40 - 31	0.126 - 0.126	43 - 40
Install cask binders, impact limiters, personnel barriers	0.010 - 0.009	15 - 12	0.056 - 0.055	19 - 18
Load SNF into cask	0.011 - 0.027	17 - 35	0.011 - 0.027	4 - 9
On-vehicle cask radiological decontamination and survey	0.003 - 0.003	5 - 4	0.018 - 0.018	6 - 6
Final inspection and radiation surveys	0.002 - 0.002	4 - 3	0.016 - 0.015	5 - 5
All other (19) activities	0.011 - 0.012	19 - 16	0.066 - 0.073	23 - 23
Task totals	*0.062 - 0.077*	*100 - 100*	*0.29 - 0.31*	*100 - 100*

a. Source: DIRS 101747-Schneider et al. (1987, p. 2.9).
b. CD/MTU = Collective dose (person-rem effective dose equivalent) per metric ton uranium. One MTU is approximately equal to 1 MTHM.
c. The at-reactor loading crew size is assumed to be 13 involved workers.
d. PWR = pressurized-water reactor; BWR = boiling-water reactor.

assumed in the DIRS 101747-Schneider et al. (1987, Section 2) study] dedicated solely to performing cask-handling work. The involved worker collective dose was calculated using the following formula:

$$\text{Collective dose (person-rem)} = A \times B \times C \times D \times E$$

where: A = number of pressurized-water or boiling-water reactor spent nuclear fuel shipments being analyzed under each transportation scenario (from Tables J-4 and J-5)

B = number of transportation casks included in a shipment (set at 1 for both transportation scenarios)

C = number of pressurized-water or boiling-water reactor spent nuclear fuel assemblies in a transportation cask (from Table J-3)

D = amount of uranium in the spent nuclear fuel assembly prior to reactor irradiation, expressed as metric tons uranium per assembly (from Table J-13)

E = involved worker-specific collective dose in person-rem/metric ton uranium for each fuel type (from Table J-13)

Because worker doses are linked directly to the number of loading operations performed, the highest average individual doses under each transportation scenario would occur at the reactor sites having the most number of shipments. Accordingly, the average individual dose impacts were calculated for the limiting site using the equation:

$$\text{Average individual dose (rem per involved worker)} = (A \times B \times C \times D \times E) \div F$$

where: A = largest value for the number of shipments from a site under each transportation scenario (from Tables J-4 and J-5)

B = number of transportation casks included in a shipment (set at 1 for both transportation scenarios)

C = number of spent nuclear fuel assemblies in a transportation cask (from Table J-3)

D = amount of uranium in the spent nuclear fuel assembly prior to reactor irradiation in metric tons uranium per assembly (from Table J-13)

E = involved worker-specific collective dose in person-rem per metric ton uranium for each fuel type (from Table J-13)

F = involved worker crew size (set at 13 persons for both transportation scenarios; from Table J-14)

J.1.3.1.2 *Radiological Impacts of DOE Spent Nuclear Fuel and High-Level Radioactive Waste Loading Operations*

The methodology used to estimate impacts to workers during loading operations for commercial spent nuclear fuel was also used to estimate impacts of loading operations for DOE spent nuclear fuel and high-level radioactive waste. The exposure factor (person-rem per MTU) for loading boiling-water reactor spent nuclear fuel in truck casks at commercial facilities was used (see Table J-14). The exposure factor for truck shipments of boiling-water reactor spent nuclear fuel was based on a cask capacity of five boiling-water reactor spent nuclear fuel assemblies (about 0.9 MTU or 0.9 MTHM). The analysis used this factor because it would result in the largest estimates for dose per operation.

J.1.3.2 Methods and Approach for Analysis of Impacts from Incident-Free Transportation

The potential exists for human health impacts to workers and members of the public from incident-free transportation of spent nuclear fuel and high level radioactive waste. *Incident-free* transportation means normal accident-free shipment operations during which traffic accidents and accidents in which radioactive materials could be released do not occur (Section J.1.4. discusses accidents). Incident-free impacts could occur from exposure to (1) external radiation in the vicinity of the transportation casks, or (2) transportation vehicle emissions, both during normal transportation.

J.1.3.2.1 *Incident-Free Radiation Dose to Populations*

The analysis used the RADTRAN 5 computer model and program (DIRS 150898-Neuhauser and Kanipe 2000, all; DIRS 155430-Neuhauser, Kanipe, and Weiner 2000, all) to evaluate incident-free impacts for populations. The RADTRAN 5 input parameters used to estimate incident-free impacts are listed in Table J-15. Through extensive review (DIRS 101845-Maheras and Pippen 1995, Section 3 and 4), DOE has determined that this program provides reasonable, but conservative, estimates of population doses for use in the evaluation of risks of transporting radioactive materials, including spent nuclear fuel and high-level radioactive waste. DOE used the previous version, RADTRAN 4, to analyze transportation impacts for other environmental impact statements (for example, DIRS 101802-DOE 1995, Volume 1, Appendix E; DIRS 101816-DOE 1997, Appendixes F and G). RADTRAN 4 was subjected to extensive review (DIRS 101845-Maheras and Pippen 1995, Sections 3 and 4). RADTRAN 5 is an upgrade to RADTRAN 4, and has been validated by comparison with dose measurements (DIRS 153967-Steinman and Kearfott 2000, all). RADTRAN 5 consistently overestimates doses from transported radioactive materials when the results are compared to measured doses. The program and associated database, using population densities from 1990 Census data escalated to 2035, calculated the collective dose to populations that live along transportation routes [within 800 meters (0.5 mile) of either side of the route]. Table J-16 lists the estimated number of people who live within 800 meters of national routes.

Table J-15. Input parameters and parameter values used for the incident-free national truck and rail transportation analysis, except stops.

Parameter	Legal-weight truck transportation	Rail transportation	Legal-weight truck and rail
Package type			Type B shipping cask
Package dimension	5.2 meters[a] long 1.0 meters diameter	5.06 meters long 2.0 meters diameter	
Dose rate			10 millirem per hour, 2 meters from side of vehicle[f]
Number of crewmen	2	5	
Distance from source to crew	3.1 meters[a]	152 meters[b]	
Speed			
Rural	88 km[c,d] per hour	64 km per hour	
Suburban	88 km/hr non-rush hour 44 km/hr rush hour	40 km per hour	
Urban	88 km/hr non-rush hour 44 km/hr rush hour	24 km per hour	
Input for stop doses: see Table J-17			
Number of people per vehicle sharing route	2	3	
Minimum and maximum distances to exposed population			30 meters to 800 meters
Population densities (persons per km²)[d]			
Rural			(e)
Suburban			(e)
Urban			(e)
One-way traffic count (vehicles per hour)			
Rural	470	1	
Suburban	780	5	
Urban	2,800	5	

a. To convert meters to feet, multiply by 3.2808.
b. Rail crew in transit would be too far and too well shielded from the external cask radiation to receive any dose. This number is not used in the calculation and is provided for information only.
c. To convert kilometers to miles, multiply by 0.62137.
d. Assumes general freight rather than dedicated service.
e. Population densities along transportation routes were estimated using the HIGHWAY and INTERLINE computer programs, then were extrapolated to 2035.
f. The actual (equivalent) input to RADTRAN 5 is 14 millirem per hour at 1 meter (3.3 feet) from the side of the vehicle.

Table J-16. Population within 800 meters (0.5 mile) of routes for incident-free transportation using 2035 population.

Transportation scenario	2035 population
Mostly legal-weight truck	10,400,000
Mostly rail	16,400,000

RADTRAN 5 uses the following information to estimate collective incident-free doses to the public:

- The external radiation dose rate around shipping casks
- The resident population density (number of people per square kilometer) in the census block groups that contain the route (from HIGHWAY or INTERLINE)
- In urban areas, a factor for nonresident population density
- The speed of the vehicle (truck or train)
- The number of shipments that would be transported over each route
- The density of vehicles (number of vehicles per kilometer) sharing the route with the shipment and the average number of people in each vehicle
- Conditions at vehicle stops, which are described in greater detail below.

Most of these parameters were developed using the data listed in Tables J-15 and J-17. The number of shipments that would use a transportation route was developed with the use of the CALVIN computer program discussed in Section J.1.1.1, the DOE Throughput Study (DIRS 100265-CRWMS M&O 1997, Section 6.1.1), data on DOE spent nuclear fuel and high-level radioactive waste inventories in Appendix A, and data from DOE sites (DIRS 104778-Jensen 1998, all). The analysis used CALVIN to estimate the number of shipments from each commercial site. The Throughput Study provided the estimated number of shipments of high-level radioactive waste from the four DOE sites. Information provided by the DOE National Spent Nuclear Fuel Program (DIRS 104778-Jensen 1998, all) and in Appendix A was used to estimate shipments of DOE spent nuclear fuel.

The analysis used a value of 10 millirem per hour at a distance of 2 meters (6.6 feet) from the side of a transport vehicle for the external dose rate around shipping casks. This value is the maximum allowed by regulations of the U.S. Department of Transportation for shipments of radioactive materials [49 CFR 173.441(b)]. Dose rates at distances greater than 2 meters from the side of a vehicle would be less. The dose rate at 30 meters (98 feet) from the vehicle would be less than 0.2 millirem per hour; at a distance of 800 meters (2,600 feet) the dose rate would be less than 0.0002 millirem per hour.

In addition, the analysis used RADTRAN 5 to estimate doses to people closer to the cask than the resident population along the route, and to people who would be exposed for longer periods of time. These populations would include the truck or rail crew, others working near the cask, people in vehicles that share the route with the shipment, members of the public at truck stops, and residents of the area near the truck and rail stops.

The analysis also uses the potential number of people close enough to shipments to be exposed to radiation from the casks. The analysis determined the estimated offlink number of people [those within the 1.6-kilometer (1-mile) region of influence] by multiplying the population densities (persons per square kilometer) in population zones through which a route would pass by the 1.6-kilometer width of the region of influence and by the length of the route through the population zones. Onlink populations (those sharing the route and people at stops along the route) were estimated using assumptions from other EISs that have evaluated transportation impacts (DIRS 101802-DOE 1995, Volume 1, Appendix I; DIRS 101812-DOE 1996, Appendix E; DIRS 101816-DOE 1997, Appendixes F and G). The travel distance in each population zone was determined for legal-weight truck shipments by using the HIGHWAY computer program (DIRS 104780-Johnson et al. 1993, all) and for rail shipments by using the INTERLINE

Table J-17. Input parameter values for stop doses for routine incident-free transportation.

Stop type	Population exposed	Minimum distance (meters)[a]	Maximum distance (meters)[a]	Stop time	Other
Doses to the public					
People at truck stops	6.9[b]	1[b]	15.8[b]	20 min[b]	845 km[c] between stops
Residents near truck stops	Rural, suburban, or urban[d]	30	800	20 min[b]	845 km between stops
Residents near truck walkaround inspections[e]	Rural, suburban, or urban	30	800	10 min	161 km between stops
Residents near rail classification stops	Rural, suburban, or urban	30	800	30 hr[a]	One stop at each end of trip
Residents near rail crew change stops	Rural, suburban, or urban	30	800	0.033 hr/km[b]	
Occupational stop doses					
Truck crew dose at rest/refuel stops	2	1	15.8	20 min	845 km between stops
Truck crew dose at walkaround inspectons	1	1	1	10 min	161 km between stops
	1	Dose rate = 2 mrem/hr by regulation			
Rail crew dose at classification stops	5	(e)		30 hr	One stop at each end of trip
Rail crew dose at crew change stops	5	Calculated by multiplying the classification stop dose by 0.0018/km: a distance-dependent worker exposure factor[f]			

a. To convert meters to feet, multiply by 3.2808.
b. Derived from DIRS 152084-Griego, Smith, and Neuhauser (1996, all).
c. km = kilometer; to convert kilometers to miles, multiply by 0.62137.
d. Values used in DIRS 152476-Sprung et al. (2000, pp. 3-5 to 3-9, Table 3.3).
e. DIRS 155430-Neuhauser, Kanipe, and Weiner (2000, Appendix B) explains this calculation, which has been incorporated into RADTRAN 5.
f. DIRS 150898-Neuhauser and Kanipe (2000, pp. 51 to 52).

program (DIRS 104781-Johnson et al. 1993, all). These programs used 1990 census block group data to identify where highways and railroads enter and exit each type of population zone, which the analysis used to determine the total lengths of the highways and railroads in each population zone.

The third kind of information—the distances individuals live from the route used in the analysis—is the estimated the number of people who live within 800 meters (about 2,600 feet) of the route. The analysis assumed that population density is uniform in population zones.

The analysis used RADTRAN 5 to calculate exposures for the following groups:

- *Public along the route (Offlink Exposure):* Collective doses for persons living or working within 0.8 kilometer (0.5 mile) on each side of the transportation route.

- *Public sharing the route (Onlink Exposure):* Collective doses for persons in vehicles sharing the transportation route; this includes persons traveling in the same or opposite direction and those in vehicles passing the shipment.

- *Public during stops (Stops):* Collective doses for people who could be exposed while a shipment was stopped en route. For truck transportation, these would include stops for refueling, food, and rest and for brief inspections at regular intervals. For rail transportation, stops would occur in railyards at the beginning and end of each trip, and along the route to switch railcars from inbound trains to outbound trains traveling toward the Yucca Mountain site, and to change train crews and equipment (locomotives).

- *Worker exposure (Occupational Exposure):* Collective doses for truck and rail transportation crew members.

- *Security escort exposure (Occupational Exposure):* Collective doses for security escorts. In calculating doses to workers the analysis conservatively assumed that the maximum number of escorts required by regulations (10 CFR 73.37) would be present for urban, suburban, and rural population zones.

The sum of the doses for the first three categories is the total nonoccupational (public) dose.

The sensitivity analysis in Section J.1.3.2.2.3 evaluates impacts of requiring additional escorts such as escorts in separate vehicles for all parts of every shipment of loaded legal-weight truck casks and two escorts in all areas for rail shipments.

Table J-17 lists input parameter values for doses to public and workers at stops. RADTRAN 5 models stops separately, and does not use the "hours per kilometer of travel" of the RADTRAN 4 model. Documentation for a stop model for dose to the public at truck rest and refueling stops is in DIRS 152084-Griego, Smith, and Neuhauser (1996, all). Models for calculating doses to members of the public who reside near stops, as well as occupational doses, for truck and rail, are in DIRS 152476-Sprung et al. (2000, pp. 8-14 to 8-18). For each model, the analysis includes a population or population density component, a total stop-time component, and the calculation, using RADTRAN 5, of an "hour per kilometer" equivalent for consistency with the unit risk factors listed in Table J-18. The external dose rate from the cask for all stops is 10 millirem per hour at 2 meters (6.6 feet) from the cask.

Unit dose factors were used to calculate incident-free collective doses. The offlink unit risk factors listed in Table J-18 represent the dose that would be received by a population density of one person per square kilometer for one shipment of radioactive material moving a distance of 1 kilometer (0.62 mile) in the indicated population density zone, and reflect the assumption that the dose rate external to shipments of spent nuclear fuel and high-level radioactive waste would be the maximum value allowed by U.S. Department of Transportation regulations—10 millirem per hour at 2 meters (6.6 feet) from the side of the transport vehicle (49 CFR 173.441). The onlink unit risk factors represent the doses that would be received by occupants of vehicles sharing the transportation route with the cargo. There are two kinds of stop dose unit risk factors: one for the resident population near stops, based on a population density of one person per square kilometer, and another for the public at rest and refueling stops, which is independent of population density. The incident-free dose from transporting a single shipment was determined by multiplying the appropriate unit dose factors by corresponding distances in each of the population zones through which the shipment route would pass and by the population density of the zone. The collective dose from all shipments from a site was determined by multiplying the dose from a single shipment by the number of shipments that would be required to transport the site's spent nuclear fuel or high-level radioactive waste to the repository. Collective dose was converted to the estimated number of latent cancer fatalities using conversion factors recommended by the International Commission on Radiological Protection (DIRS 101836-ICRP 1991, p. 22). These values are 0.0004 latent cancer fatality per person-rem for radiation workers and 0.0005 latent cancer fatality per person-rem for the general population.

J.1.3.2.2 *Methods Used To Evaluate Incident-Free Impacts to Maximally Exposed Individuals*

To estimate impacts to maximally exposed individuals, the same kinds of information as those used for population doses (except for population size) were needed. The analysis of doses to maximally exposed individuals used projected exposure times, the distance a hypothetical individual would be from a shipment, the number of times an exposure event could occur, and the assumed external radiation dose

Table J-18. Incident-free dose factors.

Factor		Barge	Heavy-haul truck	Rail	Legal-weight truck
Public					
Off-link[a] [rem per (persons per square kilometer) per kilometer]	Rural	1.72×10^{-7}	6.24×10^{-8}	3.90×10^{-8}	2.98×10^{-8}
	Suburban	1.72×10^{-7}	6.24×10^{-8}	6.24×10^{-8}	3.18×10^{-8}
	Urban	1.72×10^{-7}	6.24×10^{-8}	1.04×10^{-7}	3.18×10^{-8}
On-link[b] (person-rem per kilometer)	Rural		1.01×10^{-4}	1.21×10^{-7}	9.53×10^{-6}(c)
	Suburban		7.94×10^{-5}	1.55×10^{-6}	2.75×10^{-5}
	Urban		2.85×10^{-4}	4.29×10^{-6}	9.88×10^{-5}
Residents near rest/refueling stops (rem per person per kilometer)[d]	Rural		3.96×10^{-9}	1.24×10^{-7}	5.50×10^{-9}
	Suburban		3.96×10^{-9}	1.24×10^{-7}	5.50×10^{-9}
	Urban		3.96×10^{-9}	1.24×10^{-7}	5.50×10^{-9}
Residents near classification stops (rem per person per square kilometer)	Suburban			1.59×10^{-5}	
Public including workers at rest/refueling stops (person-rem per kilometer)					7.86×10^{-6}
Workers					
Classification stops (person-rem)				8.07×10^{-3}	
In-transit rail stops (person-rem per kilometer)				1.45×10^{-5}	
In moving vehicle (person-rem per kilometer)	Rural	2.11×10^{-6}	5.54×10^{-6}		4.52×10^{-5}
	Suburban	2.11×10^{-6}	5.54×10^{-6}		4.76×10^{-5}
	Urban	2.11×10^{-6}	5.54×10^{-6}		4.76×10^{-5}
Walkaround inspection (person-rem per kilometer)			6.27×10^{-7}		1.93×10^{-5}

a. Offlink general population includes persons in the census block groups on the route; the population density in each census block group is assumed to be the population density in the half-mile on either side of the route.
b. Onlink general population included persons sharing the road or railway.
c. Onlink dose factors are larger than offlink because the onlink population (vehicles and persons per vehicle) is included in the dose factor, and because the vehicles are much closer to the radioactive cargo.
d. The methodology, equations, and data used to develop the unit dose factors are discussed in DIRS 152084-Griego, Smith, and Neuhauser (1996, all); DIRS 155430-Neuhauser, Kanipe, and Weiner (2000, Chapter 3); and DIRS 152476-Sprung et al. (2000, Chapter 3).

rate 2 meters (6.6 feet) from a shipment (10 millirem per hour). These analyses used the RISKIND computer program (DIRS 101483-Yuan et al. 1995, all). DOE has used RISKIND for analyses of transportation impacts in other environmental impact statements (DIRS 104382-DOE 1995, Appendix J; DIRS 101812-DOE 1996, Appendix E; DIRS 101816-DOE 1997, Appendix E). RISKIND provides appropriate results for analyses of incident-free transportation and transportation accidents involving radioactive materials (DIRS 101845-Maheras and Pippen 1995, Sections 5.2 and 6.2; DIRS 102060-Biwer et al. 1997, all).

The maximally exposed individual is a hypothetical person who would receive the highest dose. Because different maximally exposed individuals can be postulated for different exposure scenarios, the analysis evaluated the following exposure scenarios.

- *Crew Members.* In general, truck crew members, would receive the highest doses during incident-free transportation (see discussions below). The analysis assumed that the crews would be limited to a total job-related exposure of 2 rem per year (DIRS 156764-DOE 1999, Article 211).

- *Inspectors (Truck and Rail).* Inspectors would be Federal or state vehicle inspectors. On the basis of information provided by the Commercial Vehicle Safety Alliance (DIRS 104597-Battelle 1998, all;

DIRS 156422-CVSA 2001, all), the analysis assumed an average exposure distance of 1 meter (3 feet) and an exposure duration of 1 hour (see discussion in J.1.3.2.2.2).

- *Railyard Crew Member.* For a railyard crew member working in a rail classification yard assembling trains, the analysis assumed an average exposure distance of 10 meters (33 feet) and an exposure duration of 2 hours (DIRS 101816-DOE 1997, p. E-50).

- *Resident.* The analysis assumed this maximally exposed individual is a resident who lives 30 meters (100 feet) from a point where shipments would pass. The resident would be exposed to all shipments along a particular route (DIRS 101802-DOE 1995, Volume 1, Appendix I, p. I-52).

- *Individual Stuck in Traffic (Truck or Rail).* The analysis assumed that a member of the public could be 1.2 meter (4 feet) from the transport vehicle carrying a shipping cask for 1 hour. Because these circumstances would be random and unlikely to occur more than once for the same individual, the analysis assumed the individual to be exposed only once.

- *Resident Near a Rail Stop.* The analysis assumed a resident who lives within 200 meters (660 feet) of a switchyard and an exposure time of 20 hours for each occurrence. The analysis of exposure for this maximally exposed individual assumes that the same resident would be exposed to all rail shipments to the repository (DIRS 101802-DOE 1995, Volume 1, Appendix I, p. I-52).

- *Person at a Truck Service Station.* The analysis assumed that a member of the public (a service station attendant) would be exposed to shipments for 49 minutes for each occurrence at a distance of 16 meters (52 feet) (DIRS 152084-Griego, Smith, and Neuhauser 1996, all). The analysis also assumed this individual would work at a location where all truck shipments would stop.

As discussed above for exposed populations, the analysis converted radiation doses to estimates of radiological impacts using dose-to-risk conversion factors of the International Commission on Radiological Protection.

J.1.3.2.2.1 Estimation of Incident-Free Maximally Exposed Individuals in Nevada. This section presents the assumptions used to estimate incident-free exposures to maximally exposed individuals in Nevada.

Transporting spent nuclear fuel to the Yucca Mountain site by legal-weight or heavy-haul trucks would require transport through Nevada on existing roads and highways. The proximity of existing structures that could house a maximally exposed individual have been determined and the maximally exposed individual identified and potential dose calculated as discussed in Section J.1.3.2.2. DOE considered a number of different sources of information concerning the proximity of the maximally exposed individual to a passing truck carrying spent nuclear fuel or high-level radioactive waste.

- An analysis prepared for the City of North Las Vegas (DIRS 155112-Berger 2000, p. 104) locates the maximally exposed individual 15 meters (50 feet) from an intersection. This individual would be exposed for 1 minute per shipment and an additional 30 minutes per year due to traffic delays. DOE believes the conditions listed greatly exceed actual conditions that would be encountered. Nevertheless, the estimated dose to this maximally exposed individual would be 530 millirem over 24 years.

- DOE performed a survey to determine the location of and proximity to the proposed routes that identified potential maximally exposed individual locations as follows:

  – Residences approximately 5 meters (15 feet) from Highway 93 in Alamo, Nevada (DIRS 155825-Poston 2001, p. 10). The analysis estimated the dose to a maximally exposed individual at this location based on 10,000 heavy-haul truck shipments over 24 years. This estimated dose would be 25 millirem.

– The courthouse and fire station in Goldfield, Nevada, are 5.5 and 4.9 meters (18 and 15 feet), respectively (DIRS 155825-Poston 2001, p. 12) from the road. The analysis estimated the dose to maximally exposed individuals at this location assuming potential exposure to 10,000 heavy-haul truck shipments over 24 years. The estimated dose would be 56 millirem.

– The width of the cleared area for a branch rail line would be 60 meters (200 feet); therefore, the closest resident would be at least 30 meters (98 feet) from a branch rail line. A maximally exposed individual who would be a minimum distance of 30 meters from a branch rail line, assuming 10,000 shipments over 24 years, would receive an estimated dose of 2 millirem.

– The *Intermodal and Highway Transportation of Low-Level Radioactive Waste to the Nevada Test Site* (DIRS 155779-DOE 1999, VI pc-23, Table C-11) identifies the maximally exposed individual as residing between Barstow, California, and the Nevada Test Site approximately 10.7 meters (35 feet) from a highway over 24 years of shipments; this individual would receive an estimated 20 millirem.

As identified above, the maximally exposed individual dose over 24 years for transportation in Nevada would range from 2 to 530 millirem.

J.1.3.2.2.2 Incident-Free Radiation Doses to Inspectors. DOE estimated radiation doses to the state inspectors who would inspect shipments of spent nuclear fuel and high-level radioactive waste originating in, passing through, or entering a state. For legal-weight truck and railcar shipments, the analysis assumed that:

- Each inspection would involve one individual working for 1 hour at a distance of 1 meter (3.3 feet) from a shipping cask.
- The radiation field surrounding the cask would be the maximum permitted by regulations of the U.S. Department of Transportation (49 CFR 173.441).
- There would be no shielding between an inspector and a cask.

For rail shipments, the analysis assumed that:

- There would be a minimum of two inspections per trip—one at origin and one at destination—with additional inspections en route occurring at intermediate stops.
- Rail crews would conduct the remaining along-the-route inspections.

For legal-weight truck shipments, the analysis assumed that:

- On average, state officials would conduct two inspections during each trip – one at the origin and one at the destination.
- The inspectors would use the Enhanced North American Uniform Inspection Procedures and Out-of-Service Criteria for Commercial Highway Vehicles Transporting Transuranics, Spent Nuclear Fuel, and High-Level Radioactive Waste (DIRS 156422-CVSA 2001, all).

- The shipments would receive a Commercial Vehicle Safety Alliance inspection sticker on passing inspection and before departing from the 77 sites.

- Display of such a sticker would provide sufficient evidence to state authorities along a route that a shipment complied with U.S. Department of Transportation regulations (unless there was contradictory evidence), and there would be no need for additional inspections.

The analysis used the RISKIND computer program (DIRS 101483-Yuan et al. 1995, all) to determine doses to state inspectors. The data used by the program to calculate dose includes the estimated value for dose rate at 1 meter (3.3 feet) from a cask surface, the length and diameter of the cask, the distance between the location of the individual and the cask surface, and the estimated time of exposure. For rail shipments, using the assumptions outlined above, the estimated value for whole-body dose to an individual inspector for one inspection would be 17 millirem. Under the mostly rail scenario in which approximately 400 rail shipments would arrive in Nevada annually, a Nevada inspector working 1,800 hours per year could inspect as many as 82 shipments in a year. This inspector would receive a dose of 1.4 rem. If this same inspector inspected 82 shipments per year over the 24 years of the Proposed Action, he or she would be exposed to 34 rem.

The use of the dose-to-risk conversion factors published by the International Commission on Radiation Protection projects this exposure to increase the likelihood of the inspector incurring a fatal cancer. The projection would add 2 percent to the likelihood for fatal cancers from all other causes, increasing the likelihood from approximately 23 percent (DIRS 153066-Murphy 2000, p. 5) to 25 percent.

For shipments by legal-weight truck, the analysis used the RISKIND computer program to estimate doses to inspectors (DIRS 101483-Yuan et al. 1995, all). The data used by the program to calculate dose includes the estimated value for dose rate at 1 meter (3.3 feet) from a cask surface, the length and diameter of the cask, the distance between the location of the individual and the cask surface, and the estimated time of exposure. For this calculation, the analysis assumed that an inspector following Commercial Vehicle Safety Alliance procedures (DIRS 156422-CVSA 2001, all) would work for 1 hour at an average distance of 1 meter (3.3 feet) from the cask. The analysis assumed that a typical legal-weight truck cask would be about 1 meter in diameter and about 5 meters (16 feet) long and that the dose rate 1 meter from the cask surface would be 14 millirem per hour. A dose rate of 14 millirem per hour 1 meter from the surface of a truck cask is approximately equivalent to the maximum dose rate allowed by U.S. Department of Transportation regulations for exclusive-use shipments of radioactive materials (49 CFR 173.441).

Using these data, the RISKIND computer program calculated an expected dose of 18 millirem for an individual inspector. Under the mostly legal-weight truck scenario in which approximately 2,200 legal-weight truck shipments would arrive in Nevada annually, a Nevada inspector working 1,800 hours per year could inspect as many as 450 shipments in a year. This inspector would receive a dose of 8.1 rem. If this same inspector inspected all shipments over the 24 years of the Proposed Action, he or she would be exposed to approximately 200 rem. However, DOE would control worker exposure through administrative procedures (see DIRS 156764-DOE 1999, Article 211). Actual worker exposure would likely be 2 rem per year, or a maximum of 48 rem over 24 years. The use of the dose-to-risk conversion factors published by the International Commission on Radiation Protection projects this exposure to increase the likelihood of this individual contracting a fatal cancer. The projection would add about 2 percent to the likelihood for fatal cancers from all other causes, increasing the likelihood from approximately 23 percent (DIRS 153066-Murphy 2000, p. 5) to 25 percent. As discussed below, however, doses to inspectors likely would be much smaller.

DOE implements radiation protection programs at its facilities where there is the potential for worker exposure to cumulative doses from ionizing radiation. The Department anticipates that the potential for individual whole-body doses such as those reported above would lead an involved state to implement such a radiation protection program. If similar to those for DOE facilities, the administrative control limit on individual dose would not exceed 2 rem per year (DIRS 156764-DOE 1999, Article 211), and the expected maximum exposure for inspectors would be less than 500 millirem per year.

Under the mostly legal-weight truck scenario, the annual dose to inspectors in a state that inspected all incoming legal-weight truck shipments containing spent nuclear fuel or high-level radioactive waste would be as much as 40 person-rem. Over 24 years, the population dose for these inspectors would be about 950 person-rem. This would result in about 0.38 latent cancer fatality (this is equivalent to a 47-percent likelihood that there would be 1 additional latent cancer fatality among the exposed group).

The EIS analysis assumed that shipments would be inspected in the state of origin and in the destination state. If each state required an inspection on entry, the total occupational dose over 24 years of operation for the mostly legal-weight truck scenario would increase from approximately 14,000 person-rem to approximately 21,000 person-rem, resulting in an additional 3 latent cancer fatalities to the occupationally exposed population.

J.1.3.2.2.3 Incident-Free Radiation Doses to Escorts. This section has been moved to Volume IV of this EIS.

J.1.3.2.3 *Vehicle Emission Impacts*

Human health impacts from exposures to vehicle exhaust depend principally on the distance traveled and on the impact factors for fugitive dust and exhaust particulates from truck (including escort vehicles) or rail emissions (DIRS 151198-Biwer and Butler 1999, all; DIRS 155786-EPA 1997, all; DIRS 155780-EPA 1993, all).

The analysis estimated incident-free impacts using unit risk factors that account for fatalities associated with emissions of pollution in urban, suburban, and rural areas by transportation vehicles, including escort vehicles. Because the impacts would occur equally for trucks and railcars transporting loaded or unloaded shipping casks, the analysis used round-trip distances. Escort vehicle impacts were included only for loaded truck shipment miles, but were included for round trips for rail escort cars.

The analysis used risk factors to estimate impacts. The factors considered the effects of population density near highways and railroads. For urban areas, the value used for truck transportation was about 5 latent fatalities per 100 million kilometers traveled (8 latent fatalities per 100 million miles) by trucks and 2 latent fatalities per 10 million kilometers traveled by railcars (3 latent fatalities per 10 million miles). For trucks traveling in suburban and rural areas, the respective risk factors used are about 3 latent fatalities in 100 million kilometers (5 in 100 million miles) and 3 in 10 billion kilometers (5 in 10 billion miles). For railcars traveling in suburban and rural areas, the respective risk factors used are about 9 latent fatalities in 100 million kilometers (1.5 in 10 million miles) and about 8 in 10 billion kilometers (1.5 in 1 billion miles).

Although the analysis estimated human health and safety impacts of transporting spent nuclear fuel and high-level radioactive waste, exhaust and other pollutants emitted by transport vehicles into the air would not measurably affect national air quality. National transportation of spent nuclear fuel and high-level radioactive waste, which would use existing highways and railroads, would average 14.2 million truck kilometers per year for the mostly truck case and 3.5 million railcar kilometers per year from the mostly rail case. The national yearly average for total highway and railroad traffic is 186 billion truck kilometers and 49 billion railcar kilometers (DIRS 148081-BTS 1999, Table 3-22). Spent nuclear fuel and high-level radioactive waste transportation would represent a very small fraction of the total national highway and railroad traffic (0.008 percent of truck kilometers and 0.007 percent of rail car kilometers). In addition, the contributions to vehicle emissions in the Las Vegas air basin, where all truck shipments (an average of five per day) would travel under the mostly legal-weight truck scenario, would be small in comparison to those from other vehicle traffic in the area. The annual average daily traffic on I-15 0.3 kilometer (0.2 mile) north of the Sahara Avenue interchange is almost 200,000 vehicles (DIRS 103405-NDOT 1997, p. 7), about 20 percent of which are trucks (DIRS 104727-Cerocke 1998, all). For these reasons, national transportation of spent nuclear fuel and high-level radioactive waste by truck and rail would not constitute a meaningful source of air pollution along the nation's highways and railroads.

J.1.3.2.4 *Sensitivity of Dose Rate to Characteristics of Spent Nuclear Fuel*

For this analysis, DOE assumed that the dose rate external to all shipments of spent nuclear fuel and high-level radioactive waste would be the maximum value allowed by regulations (49 CFR 173.441). However, the dose rate for actual shipments would not be the maximum value of 10 millirem per hour at 2 meters (6.6 feet) from the sides of vehicles. Administrative margins of safety that are established to compensate for limits of accuracy in instruments and methods used to measure dose rates at the time shipments are made would result in lower dose rates. In addition, the characteristics of spent nuclear fuel and high-level radioactive waste that would be loaded into casks would always be within the limit values allowed by the cask's design and its Nuclear Regulatory Commission certificate of compliance.

For example, DOE used data provided in the *GA-4 Legal-Weight Truck Cask Design Report* (DIRS 101831-General Atomics 1993, pp. 5.5-18 and 5.5-19) to estimate dose rates 2 meters (6.6 feet) from transport vehicles for various characteristics of spent nuclear fuel payloads. Figure J-7 shows ranges of burnup and cooling times for spent nuclear fuel payloads for the GA-4 cask. The figure indicates the characteristics of a typical pressurized-water reactor spent nuclear fuel assembly (see Appendix A). Based on the design data for the GA-4 cask, a shipment of typical pressurized-water reactor spent nuclear fuel would result in a dose rate of about 6 millirem per hour at 2 meters from the side of the transport vehicle, or about 60 percent of the limit established by U.S. Department of Transportation regulations (49 CFR 173.441). Therefore, DOE estimates that, on average, dose rates at locations 2 meters (6.6 feet) from the sides of transport vehicles would be about 50 to 70 percent of the regulatory limits. As a result, DOE expects radiological risks to workers and the public from incident-free transportation to be no more than 50 to 70 percent of the values presented in this EIS.

J.1.4 METHODS AND APPROACH TO ANALYSIS OF ACCIDENT SCENARIOS

J.1.4.1 Accidents in Loading Operations

J.1.4.1.1 *Radiological Impacts of Loading Accidents*

The analysis used information in existing reports to consider the potential for radiological impacts from accidents during spent nuclear fuel loading operations at the commercial and DOE sites. These included a report that evaluated health and safety impacts of multipurpose canister systems (DIRS 104794-CRWMS M&O 1994, all) and two safety analysis reports for onsite dry storage of commercial spent nuclear fuel at independent spent fuel storage installations (DIRS 103449-PGE 1996, all; DIRS 103177-CP&L 1989, all). The latter reports address the handling and loading of spent nuclear fuel assemblies in large casks similar to large transportation casks. In addition, DOE environmental impact statements on the management of spent nuclear fuel and high-level radioactive waste (DIRS 101802-DOE 1995, all; DIRS 101816-DOE 1997, all) provided information on radiological impacts from loading accidents.

DIRS 104794-CRWMS M&O (1994, Sections 3.2 and 4.2) discusses potential accident scenario impacts of four cask management systems at electric utility and other spent nuclear fuel storage sites. This report concentrated on unplanned contact (bumping) during lift-handling of casks, canisters, or fuel assemblies. The two safety analysis reports for independent spent fuel storage installations for commercial spent